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(54) **MOBILE COMMUNICATION SYSTEM, MOBILE STATION, BASE STATION, COMMUNICATION PATH QUALITY ESTIMATION METHOD USED FOR THE SAME**

(57) A mobile communication system capable of improving the system throughput. A base station (1) divides one cell into three sectors. A common pilot channel is transmitted to a plurality of mobile stations in the sectors by beams (101-103) whose directivity is controlled by an adaptive antenna for each of the sectors. On the other hand, when a mobile station (2) communicates data with the base station (1), the base station transmits a data channel and an individual control channel to the mobile station (2) by using a beam (201) whose directivity is controlled individually. The mobile station (2) switches between the common pilot channel and the individual control channel from the base station (1) for estimating the communication path quality.

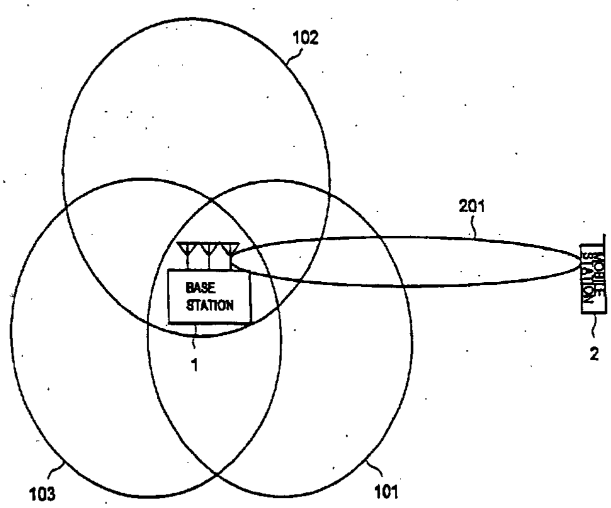

FIG. 2

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Description

Technical Field

[0001] The present invention relates to a mobile communication system, a mobile station, a base station, and a communication path quality estimation method for use therein and, in particular, relates to a method of estimating a communication path quality in a mobile communication system.

Background Art

[0002] Following the increase in demand for data communications, high-speed large-capacity downlink packet systems have been actively studied. For example, in the next generation mobile communication system (IMT-2000), the high speed downlink packet transmission (HSDPA: High Speed Downlink Packet Access) using the W-CDMA (Wide band-Code Division Multiple Access) has been discussed in the 3GPP (3rd Generation Partnership Project).

[0003] In the HSDPA, a high speed downlink shared channel (HS-PDSCH: High Speed-Physical Downlink Shared Channel) is used for downlink transmission from a base station to a mobile station. The HS-PDSCH is for transmitting packet data, and a plurality of mobile stations can use one HS-PDSCH in a shared manner by temporally sharing (time-sharing) it.

[0004] In the HSDPA system, uplink control channels (HS-DPCCH: High Speed-Dedicated Physical Control Channel) are set between a base station and a plurality of mobile stations for controlling data transmission from the base station to the mobile stations. The HS-DPCCH is used by the mobile station for transmitting ACK/NACK information about an HARQ (Hybrid Automatic Repeat reQuest) and communication path quality information to the base station.

[0005] The communication path quality represents a signal power to interference power ratio (SIR: Signal to Interference Ratio) of a common pilot signal (CPICH: Common Pilot Channel). Here, since all channels are temporally multiplexed and transmitted, the mobile stations each can use the common pilot channel transmitting known data symbols, so as to measure the reception quality.

[0006] The HSDPA system uses the AMCS (Adaptive Modulation and Coding Scheme) that adaptively changes modulation and coding rate according to a notified communication path quality. When the AMCS is applied, it is possible to carry out transmission that depends on the communication path quality. Specifically, when the communication path quality is excellent, the throughput can be improved by applying a modulation system with a large multilevel value and an error correcting code with a large coding rate while, when it is poor, the packet error rate can be suppressed by reducing both the multilevel value and the coding rate, so that it is possible to increase the system capacity.

[0007] In the packet transmission like the HSDPA, after receiving data transmission requests from a plurality of mobile stations, a base station determines transmission order among the mobile stations (scheduling) and transmits data. In this scheduling, use is made of communication path qualities notified from the mobile stations. The scheduling that performs packet transmission preferentially to such a mobile station with a high communication path quality is called a Maximum C/I scheduler.

[0008] When the Maximum C/I scheduler is used, transmission is performed in an instant when the communication path quality is high. Therefore, when the AMCS is applied, the probability of selecting a higher MCS level increases to thereby raise the average value of transmission rates, so that it is possible to increase the system throughput.

[0009] Further, apart from the communication system, an adaptive antenna enables separation of signals by the use of its directivity and, when applied to downlink communication, enables reduction in interference. Therefore, by applying the adaptive antenna to a downlink common channel that transmits packet data, the power can be transmitted convergently only in the direction of a mobile station so that it is possible to reduce interference to other users.

[0010] Conventionally, in case where the adaptive antenna is not applied to downlink transmission, the communication path quality observed by a mobile station does not rely on the state of communication. However, when the adaptive antenna is applied thereto, since a data channel is transmitted only in the direction controlled by the directivity, although the data channel is subjected to multipath interference while packet transmission is carried out, the data channel is not subjected to multipath interference while packet transmission is not carried out. This is because data channels of other mobile stations are separated by the directivity so that interference power is reduced. That is, the communication path quality observed by the mobile station relies on the state of communication.

[0011] In the foregoing conventional mobile communication system, the common pilot channel is used as a channel for estimating the communication path quality that is notified to the base station from the mobile station. However, there arises a problem that since the common pilot channel is not transmitted to a particular mobile station with a directivity given thereto, the communication path differs from a channel that actually transmits packets so that there occurs a difference between the estimated communication path quality and a communication path quality upon reception.

[0012] Further, a dedicated control channel controlled in directivity and given to each of users that carry out packet communication may be used for communication path quality estimation. However, if the control channels are allocated

to all users in communication and on standby to carry out the communication path quality measurement, signal power to be allocated to the users on standby, which is not primarily necessary, increases and this causes interference to the users receiving packets. Thus, there is no merit of applying the adaptive antenna. Alternatively, if, as conventional, dedicated control channels controlled in directivity and given to only, those users receiving packets are used for the communication path quality estimation, there is a problem that the communication path quality estimation cannot be carried out while waiting for packets.

[0013] Further, in the foregoing conventional mobile communication system, although MCS selection is carried out based on the communication path quality, when the adaptive antenna is used, the data channels of other mobile stations are separated in a standby state by the directivity of the adaptive antenna, and therefore, it is not possible to know degradation of the communication path quality due to multipath interference to the data channel in a communication state.

[0014] Consequently, in the conventional mobile communication system, there arises a problem that the communication path quality measured in the standby state becomes higher than the communication path quality in the communication state, and therefore, if MCS selection is carried out based on the communication path quality measured in the standby state, the probability of occurrence of packet reception errors becomes high so that the transmission efficiency is reduced.

[0015] Further, in the conventional mobile communication system, it is important to use the communication path qualities measured in the same condition over all mobile stations when carrying out the scheduling, but, when the adaptive antenna is used, the communication path quality differs depending on the communication state of the mobile station.

[0016] Conventionally, the interference power used for estimation of the communication path quality is not measured instantaneously, but the average value is derived over a predetermined time. The communication path quality becomes poorer with respect to such a mobile station that performs packet transmission at a higher time rate in the predetermined time. That is, the communication path quality differs depending on the communication state (the rate of time in which packet transmission is carried out). Therefore, in the conventional method, there arises a problem that it is not possible to perform the comparison in the same condition.

[0017] Further, since interference to the data channel from other mobile stations is small in the standby state by means of the directivity, the communication path quality is measured better than in the communication state. When there exist a mobile station in the standby state and a mobile station in the communication state at the same time, the communication path quality notified by the mobile station in the standby state becomes high while the communication path quality notified by the mobile station in the communication state becomes low.

[0018] In this event, the Maximum C/I scheduler transmits data to the mobile station with the high communication path quality to bring it into the communication state and stops data transmission to the mobile station with the low communication path quality to bring it into the standby state. At the next time, the states are switched between these mobile stations. In the state where the states are further switched, the scheduler changes the states of the mobile stations by using notified communication path qualities, and therefore, there occurs a phenomenon that the standby state and the communication state are alternately switched between the mobile stations.

[0019] Here, since the MCS level of the mobile station brought into the communication state is determined on the basis of the communication path quality in the standby state, the probability of occurrence of packet errors increases, which further brings about an increase in the number of times of retransmission. Consequently, there arises a problem that the system throughput is reduced.

[0020] It is an object of the present invention to provide a mobile communication system, a mobile station, a base station, and a communication path quality estimation method for use therein that can improve the system throughput.

[0021] Further, it is another object of the present invention to provide a mobile communication system, a mobile station, a base station, and a communication path quality estimation method for use therein that can estimate a communication path quality in a constant condition that does not rely on a communication state immediately before.

Disclosure of the Invention

[0022] A mobile communication system according to the present invention is a mobile communication system that uses an adaptive antenna in a base station and carries out downlink data transmission to a mobile station,

wherein the mobile station comprises means for estimating a communication path quality by switching between a downlink common pilot channel transmitted with a first directivity and a downlink dedicated control channel transmitted with a second directivity, and means for notifying an estimation result thereof to the base station, and the base station comprises means for performing a communication control based on the communication path quality.

[0023] A mobile station according to the present invention is a mobile station to which downlink data transmission is carried out from a base station using an adaptive antenna, the mobile station comprising means for estimating a communication path quality by switching between a downlink common pilot channel transmitted with a first directivity

and a downlink dedicated control channel transmitted with a second directivity.

[0024] A base station according to the present invention is a base station that carries out downlink data transmission to a mobile station by the use of an adaptive antenna, the base station comprising means for performing a communication control based on a result of estimation of a communication path quality from the mobile station, the estimation carried out by switching between a downlink common pilot channel transmitted with a first directivity and a downlink dedicated control channel transmitted with a second directivity.

[0025] A communication path quality estimation method according to the present invention is a communication path quality estimation method of a mobile communication system that uses an adaptive antenna in a base station and carries out downlink data transmission to a mobile station, wherein a step of estimating a communication path quality by switching between a downlink common pilot channel transmitted with a first directivity and a downlink dedicated control channel transmitted with a second directivity, and a step of notifying an estimation result thereof to the base station are provided in the mobile station.

[0026] That is, with respect to the mobile communication system that applies the adaptive antenna to the base station and carries out the high speed downlink packet transmission, the mobile communication system according to the present invention is characterized in that the mobile station estimates the communication path quality by switching between the common pilot channel and the dedicated control channel.

[0027] With this arrangement, in the mobile communication system of the present invention, even when the base station performs a directivity control for packet data transmission which is different from that of the common pilot channel, since the mobile station can estimate the communication path quality and notify it to the base station, such a control is enabled that matches the communication path quality of a channel that carries out packet data transmission.

[0028] A mobile communication system according to the present invention is a mobile communication system including a plurality of mobile stations, and a base station for transmitting data to the plurality of mobile stations, respectively, wherein each of the mobile stations receives the data, measures a first communication path quality in a data receiving state and a second communication path quality in a data waiting state, and notifies information corresponding to a measurement result thereof to the base station, and the base station controls transmission of the data depending on a notification thereof, the mobile communication system comprising means for performing a transmission control of the data by the use of both the first communication path quality and the second communication path quality.

[0029] A mobile station according to the present invention is a mobile station of a mobile communication system including a plurality of mobile stations, and a base station for transmitting data to the plurality of mobile stations, respectively, wherein each of the mobile stations receives the data, measures a first communication path quality in a data receiving state and a second communication path quality in a data waiting state, and notifies information corresponding to a measurement result thereof to the base station, and the base station controls transmission of the data depending on a notification thereof, the mobile station comprising means for notifying the base station of information corresponding to both the first communication path quality and the second communication path quality.

[0030] A base station according to the present invention is a base station of a mobile communication system including a plurality of mobile stations, and a base station for transmitting data to the plurality of mobile stations, respectively, wherein each of the mobile stations receives the data, measures a first communication path quality in a data receiving state and a second communication path quality in a data waiting state, and notifies information corresponding to a measurement result thereof to the base station, and the base station controls transmission of the data depending on a notification thereof, the base station comprising means for performing a transmission control of the data by the use of both the first communication path quality and the second communication path quality.

[0031] A communication path quality estimation method according to the present invention is a communication path quality estimation method of a mobile communication system including a plurality of mobile stations, and a base station for transmitting data to the plurality of mobile stations, respectively, wherein each of the mobile stations receives the data, measures a first communication path quality in a data receiving state and a second communication path quality in a data waiting state, and notifies information corresponding to a measurement result thereof to the base station, and the base station controls transmission of the data depending on a notification thereof, the communication path quality estimation method using both the first communication path quality and the second communication path quality in a transmission control of the data.

[0032] That is, with respect to the system that uses the adaptive antenna in the base station and carries out the high speed downlink packet transmission, the mobile communication system of the present invention is characterized in that the mobile station performs the communication control by cooperatively using the communication path quality in the standby state and the communication path quality in the receiving state. With this arrangement, in the present invention, the estimation accuracy of the communication path quality at the start of communication is improved so that the communication control with higher accuracy is made possible.

Brief Description of the Drawings

[0033]

Fig. 1 is a diagram showing a channel structure of a mobile communication system according to a first embodiment of the present invention.
Fig. 2 is a block diagram showing a structure of the mobile communication system according to the first embodiment of the present invention.
Fig. 3 is a block diagram showing a structure of a mobile station in Fig. 2.
Fig. 4 is a block diagram showing a structure of a quality estimating section in Fig. 3.
Fig. 5 is a block diagram showing a structure of a base station in Fig. 2.
Fig. 6 is a flowchart showing operation of the mobile station in Fig. 2.
Fig. 7 is a flowchart showing operation of the base station in Fig. 2.
Fig. 8 is a flowchart showing operation of a mobile station according to a second embodiment of the present invention.
Fig. 9 is a block diagram showing a structure of a base station according to a third embodiment of the present invention.
Fig. 10 is a flowchart showing operation of the base station in Fig. 9.
Fig. 11 is a block diagram showing a structure of a base station according to a fourth embodiment of the present invention.
Fig. 12 is a flowchart showing operation of the base station in Fig. 11.
Fig. 13 is a timing chart showing timings among channels in a fifth embodiment of the present invention.
Fig. 14 is a block diagram showing a structure of a mobile station in Fig. 2.
Fig. 15 is a block diagram showing a structure of a communication path quality estimating section in Fig. 14.
Fig. 16 is a block diagram showing a structure of a base station in Fig. 2.
Fig. 17 is a block diagram showing a structure of a mobile station according to a sixth embodiment of the present invention.
Fig. 18 is a block diagram showing a structure of a base station according to the sixth embodiment of the present invention.
Fig. 19 is a block diagram showing a structure of a mobile station according to a seventh embodiment of the present invention.
Fig. 20 is a block diagram showing a structure of a base station according to the seventh embodiment of the present invention.
Fig. 21 is a flowchart showing correction processing for a communication path quality in a base station according to a ninth embodiment of the present invention.
Fig. 22 is a flowchart showing correction processing for a communication path quality in a mobile station according to a tenth embodiment of the present invention.

Best Mode for Carrying Out the Invention

[0034] Next, description will be given about embodiments of the present invention with reference to the drawings. Fig. 1 is a diagram showing a channel structure of a mobile communication system according to a first embodiment of the present invention. In Fig. 1, the mobile communication system according to the first embodiment of the present invention comprises a base station 1 and a plurality of mobile stations 2.
[0035] In this embodiment, the COMA (Code Division Multiple Access) system is used as a radio access system. The base station 1 transmits a large quantity of packeted data to the mobile station 2 by the use of a high speed downlink shared channel called HS-PDSCH (High Speed-Physical Downlink Shared Channel). The data transmitted to the mobile station 2 reaches from a communication network (not illustrated) via a radio network controller (not illustrated) connected to the base station 1.
[0036] When it is necessary to transmit a large quantity of data to the plurality of mobile stations 2, the base station 1 carries out scheduling to determine order of data transmission to the respective mobile stations 2, and transmits the data to the respective mobile stations 2 in order. In this manner, one HS-PDSCH is used among the mobile stations in a time-shared manner.
[0037] The base station 1 sets an uplink dedicated control channel (UL-DPCH: Up Link-Dedicated Physical Channel) and a downlink dedicated control channel (DL-DPCH: Down Link-Dedicated Physical Channel) for exchanging information that serves for controlling data transmission to the mobile station 2. Further, the base station 1 transmits a common pilot channel (CPICH: Common Pilot Channel) at a predetermined power.
[0038] Fig. 2 is a block diagram showing a structure of the mobile communication system according to the first

embodiment of the present invention. As shown in Fig. 2, the base station 1 transmits different common pilot channels by respective beams 101 to 103 that are controlled in directivity by adaptive antennas. When the base station 1 transmits data to the mobile station 2, the base station 1 transmits the data channel (HS-PDSCH) and the downlink dedicated control channel (DL-DPCH) by the use of a beam 201 individually controlled in directivity. The mobile station 2 estimates a communication path quality by switching between the common pilot channel (CPICH) and the dedicated control channel.

[0039] Fig. 3 is a block diagram showing a structure of the mobile station 2 in Fig. 2. In Fig. 3, the mobile station 2 comprises an antenna 21, a transmission/reception duplex section (DUP: duplexer) 22, a receiving section (Rx) 23, a channel (CH) selecting section 24, a communication path estimating section 25, a user data detecting section 26, a quality estimating section 27, a signal combining section 28, and a transmission section (Tx) 29.

[0040] Fig. 4 is a block diagram showing a structure of the quality estimating section 27 in Fig. 3. In Fig. 4, the quality estimating section 27 comprises delay devices 271-1 to 271-(K-1), despreaders 272-1 to 272-K, a Rake combining section 273, a multiplier 274, a complex conjugate means 275, a pilot symbol reproducing section 276, an averaging section 277, a mean square processing section 278, a squaring section 279, an adder 280, and an SIR (Signal to Interference Ratio) calculating section 281.

[0041] Referring to Figs. 3 and 4, the structure of the mobile station 2 will be described. A signal received at the antenna 21 is inputted into the receiving section 23 by means of the transmission/reception duplex section 22 so as to be converted into a baseband signal. An output of the receiving section 23 is inputted into the channel selecting section 24 serving for communication path quality estimation, the quality estimating section 27, the communication path estimating section 25 that carries out communication path estimation of the user data channel, and the user data detecting section 26, respectively.

[0042] The communication path estimating section 25 derives a communication path factor of the user data channel and then notifies it to the user data detecting section 26. The user data detecting section 26 despreads the baseband signal inputted from the receiving section 23, demodulates user data by using the result of the communication path estimating section 25, and outputs the user data. The channel selecting section 24 makes a selection depending on the communication state as to which of the common pilot channel and the dedicated control channel is to be used for quality estimation of a communication path, and notifies the quality estimating section 27 of selection information indicative of which of the channels is to be used.

[0043] The quality estimating section 27 despreads the received signal by using the notified result of the channel selecting section 24 to thereby estimate a communication path quality of the channel. The structure of the quality estimating section 27 is as shown in Fig. 4.

[0044] In the quality estimating section 27, the received signal is delayed by the delay devices 271-1 to 271-(K-1) depending on path timing and inputted into the despreaders 272-1 to 272-K. Here, K represents the number of multipaths.

[0045] The despreaders 272-1 to 272-K select a code for use in despreading on the basis of the information (channel selection information) notified from the channel selecting section 24. Despread signals are combined by the Rake combining section 273 to thereby obtain a demodulation result. Since pilot symbols of both the common pilot channel and the dedicated control channel are known, the symbols can be reproduced in the pilot symbol reproducing section 276 synchronously with the timing.

[0046] The complex conjugate means 275 produces complex conjugates of the symbols reproduced in the pilot symbol reproducing section 276, and the multiplier 274 multiplies the demodulated signal from the Rake combining section 273 and the complex conjugates from the complex conjugate means 275 together. Among signals as a result of the multiplication per symbol, desired signal components all have the same phase.

[0047] Averaging and mean square calculation among slots are carried out in the averaging section 277 and the mean square processing section 278. An output of the averaging section 277 represents the mean amplitude of the desired signal components, while an output of the mean square processing section 278 represents the power of the whole received signal including a desired signal and interference signals.

[0048] The desired signal power is derived by the squaring section 279 and, by subtracting it from the result of the mean square processing section 278 by the use of the adder 280, an interference component is derived. The SIR calculating section 281 derives a ratio between the desired signal power from the squaring section 279 and the interference component from the adder 280 and sends its result to the signal combining section 28 as control information.

[0049] The result of the quality estimating section 27 is inputted into the signal combining section 28 as the control information along with uplink user data and sent to the transmission section 29. The transmission section 29 performs modulation of a signal to be transmitted, and this modulated signal is transmitted to the base station 1 from the transmission/reception duplex section 21.

[0050] Fig. 5 is a block diagram showing a structure of the base station 1 in Fig. 2. In Fig. 5, the base station 1 comprises antennas 11 to 13, a transmission/reception duplex section (DUP) 14, a receiving section (Rx) 15, an information separating section 16, an MCS (Modulation and Coding Scheme) level control section 17, a signal combining

section 18, and a transmission section (Tx) 19.

[0051] Signals received at the antennas 11 to 13 are inputted into the receiving section 15 via the transmission/reception duplex section 14. The receiving section 15 sends a demodulation result to the information separating section 16. The information separating section 16 separates the uplink signals into control information and user data included therein.

[0052] Based on quality information included in the control information separated in the information separating section 16, the MCS level control section 17 determines a modulation system and a coding system for downlink, produces its result and control information, and sends them to the signal combining section 18. The signal combining section 18 combines the control information and user data to produce transmission information. The transmission information is applied with modulation in the transmission section 19 and transmitted to the mobile stations 2 via the transmission/reception duplex section 14.

[0053] Fig. 6 is a flowchart showing operation of the mobile station 2 in Fig. 2, while Fig. 7 is a flowchart showing operation of the base station 1 in Fig. 2. Referring to Figs. 2 to 7, the operation of the first embodiment of the present invention will be described. First, the operation of the mobile station 2 will be described. Fig. 6 shows the operation when a time is used as selection means.

[0054] When data is received (step S1 in Fig.6), the mobile station 2 demodulates user data if present (step S3 in Fig. 6). Further, in selection of a channel to be used for estimation of the communication path quality, the mobile station 2 checks an elapsed time from a time instant when the user data was last received (step S2 in Fig. 6).

[0055] When a predetermined time has elapsed, the mobile station 2 uses the common pilot channel for quality estimation (step S4 in Fig. 6), while, when the user data is being received, the mobile station 2 uses the dedicated control channel for quality estimation (step S5 in Fig. 6), and the mobile station 2 uses a last estimated value within the predetermined time.

[0056] Until the user data is finished (step S6 in Fig. 6), the mobile station 2 repeats the foregoing operation. Here, the predetermined time can be determined, for example, depending on a moving speed of the mobile station 2.

[0057] Next, the operation of the base station 1 will be described with reference to Fig. 7. Prior to starting transmission of user data, the base station 1 judges whether or not the quality information from the mobile station 2 has changed (step S11 in Fig. 7). If the same as the last report, the base station 1 does not change the MCS level, but modulates the user data with the last MCS level and transmits it (step S13 in Fig. 7).

[0058] If there is a change in the quality information, the base station 1 selects an MCS level depending on the quality (step S12 in Fig. 7) and transmits the user data by modulating it using the newly selected MCS level. Until there is no data left to be transmitted to the mobile station 2 (step S14 in Fig. 7), the base station 1 repeats the foregoing processing.

[0059] As described above, in this embodiment, the mobile station 2 estimates the communication path quality by switching between the pilot channel individually controlled in directivity and the common pilot channel and selects the MCS level on the basis of its result, so that the system throughput can be improved.

[0060] This is because, since the selection of the MCS level that is the highest within the range satisfying the desired error rate can be realized, the improvement in system throughput can be achieved.

[0061] The reason thereof will be described in detail. First, the dedicated pilot channel is transmitted with the same directivity as that of packet data and is thus propagated in the same communication path. Therefore, the communication path quality of the dedicated pilot channel precisely represents the channel of the packet data, and therefore, the estimation accuracy can be improved as compared with the conventional system where the communication path quality is estimated only by the common pilot channel.

[0062] Further, when the dedicated pilot channel is not present, i.e. while waiting for packet data, approximate estimation of the communication path quality can be carried out by estimation using the common pilot channel. Here, the dedicated pilot channel is allocated when packets are transmitted again, so that, by switching the channel to be used from the common pilot channel with poor estimation accuracy to the dedicated pilot channel, it is possible to improve the estimation accuracy of the communication path quality.

[0063] From these points of view, in this embodiment, the optimum MCS level can be selected by improving the estimation accuracy of the communication path quality. Further, since a switching criterion the mobile station 2 uses in the quality estimation can be independently set by the mobile station 2 without receiving a notification from the base station 1, it is also a merit that an extra control from the base station 1 to the mobile station 2 is unnecessary so that the control is simple.

[0064] Fig. 8 is a flowchart showing operation of a mobile station according to a second embodiment of the present invention. The mobile station according to the second embodiment of the present invention is the same as the foregoing first embodiment of the present invention except that a reception quality of a common channel is used as selection means for a channel. Since structures of a system, a base station, and a mobile station are the same as those in the first embodiment of the present invention shown in Figs. 1 to 5, respectively, the operation of the mobile station according to the second embodiment of the present invention will be described with reference to Figs. 1 to 5 and 8.

[0065] When data is received (step S21 in Fig. 8), a mobile station 2 demodulates user data if present (step S23 in

Fig. 8). In selection of a channel to be used for estimation of a communication path quality, the mobile station 2 checks whether or not the reception quality of the common channel has changed, for detecting a change in environment (step S22 in Fig. 8).

[0066] When there is a change in reception quality of the common channel, the mobile station 2 uses the common pilot channel for quality estimation (step S24 in Fig. 8), while, when there is no change in reception quality of the common channel, the mobile station uses a dedicated control channel for quality estimation (step S25 in Fig. 8).

[0067] Until the user data is finished (step S26 in Fig. 8), the mobile station 2 repeats the foregoing operation. Here, since the change in environment agrees with the change in communication state, the proper channel selection can be carried out.

[0068] Fig. 9 is a block diagram showing a structure of a base station according to a third embodiment of the present invention. Since structures of a system and a mobile station in the third embodiment of the present invention are the same as those in the first embodiment of the present invention, description thereof is omitted.

[0069] In Fig. 9, the base station according to the third embodiment of the present invention comprises antennas 11 to 13, a transmission/reception duplex section (DUP) 14, a receiving section (Rx) 15, mobile station corresponding units 31-1 to 31-3, a scheduling control section 32, and a transmission section (Tx) 19.

[0070] Further, the mobile station corresponding units 31-1 to 31-3 comprise information separating sections 16-1 to 16-3 (information separating sections 16-2 and 16-3 are not illustrated), MCS level control sections 17-1 to 17-3 (MCS level control sections 17-2 and 17-3 are not illustrated), and signal combining sections 18-1 to 18-3 (signal combining sections 18-2 and 18-3 are not illustrated).

[0071] Signals received at the antennas 11 to 13 are inputted into the receiving section 15 serving for respective mobile stations via the transmission/reception duplex section 14 and demodulated in the receiving section 15. The signals demodulated in the receiving section 15 are inputted into the signal separating sections 16-1 to 16-3 so as to be separated into user data and control signals.

[0072] Based on the separated control signals, MCS levels are set in the MCS level control sections 17-1 to 17-3. The MCS level and the communication path quality per mobile station are inputted into the scheduling control section 32. In the scheduling control section 32, those mobile stations to which transmission is to be made are determined on the basis of the communication path qualities notified from the mobile stations and the determined MCS levels. The MCS level information and the control information are inputted into the signal combining sections 18-1 to 18-3.

[0073] The signal combining sections 18-1 to 18-3 of the mobile stations determined for transmission combine together transmission data and control signals and notify them to the transmission section 19. The transmission section 19 converts the outputs of the signal combining sections 18-1 to 18-3 serving for respective mobile stations and multiplexes them, and transmits them via the transmission/reception duplex section 14.

[0074] Fig. 10 is a flowchart showing operation of the base station in Fig. 9. Referring to Figs. 9 and 10, description will be given about the operation of the base station according to the third embodiment of the present invention.

[0075] The base station carries out resetting of the MCS level based on the communication path quality notified from the mobile station. If there is no change in communication path quality (step S31 in Fig. 10), the base station notifies the quality information to the scheduling control section 32. If there is a change in communication path quality (step S31 in Fig. 10), the base station resets the MCS level (step S32 in Fig. 10) and notifies the scheduling control section 32 of a communication path quality and a new MCS level.

[0076] The scheduling control section 32 carries out scheduling of packet transmission by the use of the MCS level and the communication path quality that are notified per mobile station, to thereby determine to which mobile station packets are transmitted at the next time (step S33 in Fig. 10). The determination result of the scheduling control section 32 is notified per mobile station so that transmission data and control information are combined together according to the MCS level per mobile station so as to be transmitted (step S34 in Fig. 10).

[0077] Until there is no transmission data left (step S35 in Fig. 10), the base station carries out the foregoing MCS level setting and the foregoing scheduling of packet transmission.

[0078] In this embodiment, the scheduling can be efficiently performed with notifications of proper communication path qualities from the mobile stations. On the other hand, as shown in Fig. 6 or 8, the mobile station can notify the base station of the communication path quality based on the judgment criterion that is used in the communication path quality estimation.

[0079] As described above, in this embodiment, the mobile stations each switch between the channels that are used in estimation of the communication path quality and the base station performs the scheduling based on such qualities, and therefore, the selection of MCS levels and the scheduling based on those MCS levels can be realized on the basis of the communication path quality estimation with high estimation accuracy so that it is possible to improve the system throughput.

[0080] First, like in the first embodiment of the present invention, the mobile station can notify the base station of a highly accurate estimated value of the communication path quality. Next, the base station carries out scheduling of packets by using the result of the highly accurate communication path quality estimation. Inasmuch as the MCS levels

used in the scheduling can satisfy a desired error rate, the packet error rate can also satisfy a desired value, and therefore, the number of times of retransmission of packets can be reduced. As a result, the system throughput is improved.

[0081] Fig. 11 is a block diagram showing a structure of a base station according to a fourth embodiment of the present invention. Since structures of a system and a mobile station in the fourth embodiment of the present invention are also the same as those in the foregoing first embodiment of the present invention, description thereof is omitted.

[0082] In Fig. 11, the base station according to the fourth embodiment of the present invention comprises antennas 11 to 13, a transmission/reception duplex section (DUP) 14, a receiving section (Rx) 15, an information separating section 16, a spreading rate control section 33, a signal combining section 18, and a transmission section (Tx) 19.

[0083] Signals received at the antennas 11 to 13 are inputted into the receiving section 15 via the transmission/reception duplex section 14 and demodulated in the receiving section 15, and a result thereof is sent to the signal separating section 16. In the signal separating section 16, control information and user data included in the uplink signals are separated from each other.

[0084] The spreading rate control section 33 determines a downward spreading rate based on quality information included in the control information, produces its result and control information, and sends them to the signal combining section 18. The signal combining section 18 combines together the control information and user data to produce transmission information. The transmission information is modulated in the transmission section 19 and transmitted to mobile stations via the transmission/reception duplex section 14.

[0085] Fig. 12 is a flowchart showing operation of the base station in Fig. 11. Referring to Figs. 10 and 12, description